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ABSTRACT

Selected results from an aptitude-treatment interaction (ATI) study illustrate the importance of including class analyses in ATI research. The interactive effects of motivational aptitude (including locus of control, academic self confidence, and interests) and cognitive aptitude (as measured by a learning task and the Lorge-Thorndike verbal and nonverbal intelligence tests) on learning performance and on motivation were investigated in entire fourth and fifth grade classes. In one treatment, students completed workbook activities according to a structured schedule. In the other treatment, they were allowed to choose time periods, within a two-week period, to complete the work; and to complete it in any order they chose. Both treatments were administered to the classes studied. Simple regression analyses on selected aptitude-outcome pairs were conducted by treatment across all subjects, by treatment within each class, and by treatment between classes (using half-class means). Results generally indicated that classes having high ability and high academic self confidence benefitted from choosing their activities, while low ability, and low confidence students performed better in structured situations. Considerable variation between classrooms was also found. (Implications for future research and methodologies are discussed). (Author/GDC)

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CLASS EFFECTS IN ATI'S

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A paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, California, April 8-12, 1979.

Class Effects in ATI's

Selected results from an ATI study are presented in support of the importance of including class analyses in ATI research. The study investigated the interactive effects on performance and motivation of four motivational aptitudes and two cognitive aptitudes with a choice vs. no-choice treatment manipulation. Both treatments were implemented in each of nine fourth or fifth grade classrooms (n=165) over a four week period. Three sets of simple regression results (by treatment, within class, and between class) highlighted the differential effects of treatment on individuals vs. classes and suggested substantive hypotheses about these effects.

Cronbach and Snow's (1977) "radical reappraisal of the ATI model" (p. 99) emphasized the importance of separating between class from within class effects in ATI studies. This reappraisal suggested that instructional treatments may interact with classroom characteristics, as well as with individual learner aptitudes. That is, for some interactions an individual's membership in a particular type of classroom is the determining independent variable, rather than his/her relative standing on an aptitude characteristic. Or, in other instances, interactive effects are determined by a combination of an individual's standing on an aptitude characteristic and relevant classroom characteristics.

Cronbach and Webb (1977) and Gustafsson (1978) both investigated class effects (utilizing analyses based on class means) in addition to overall treatment effects (utilizing analyses based on individuals). In both studies, significant interactions in the within treatment analyses changed or disappeared when class effects were taken into account. These

studies indicated that separation of between class and within class effects can contribute to the substantive understanding of interactional effects as well as "help track anamolies in the data" (Gustafsson, 1978, p. 142). Gustafsson for example, attributed the different results from his within treatment and his within class analyses to the particular sensitivity of a paired associate aptitude measure to testing conditions.

Although limited by small sample sizes, the data below are presented as further evidence for the importance of including between class analyses in ATI studies. The data presented also suggest an ATI methodology by which class effects can be more completely analyzed. In this methodology, both treatments are implemented in each classroom, rather than assigning whole classes to one treatment (as has been customary in ATI research). With this methodology, class x aptitude and class x aptitude x treatment interactions are distinguishable. The data in this paper represent selected results from a larger ATI study (Greene, 1976), the significant components of which are first briefly described.

The ATI Study

Theoretical Framework

Though softened by time the voices of radical educators (e.g., Kozol, 1967, 1972), who called so loudly a decade ago for increased student choice and control over their own learning activities, can still be heard. Moreover, the widespread existence of such educational alternatives as open classrooms and self-paced instruction attests to the

large numbers of people who listened to these voices and accepted what they said. However, educational alternatives that incorporate a significant degree of student choice rest on the untested assumption that all children can make wise educational choices, i.e., choices that facilitate the attainment of both cognitive and socioemotional educational goals (Holt, 1964; Dennison, 1969). The present study was designed to test this assumption, using the framework of research on aptitude x treatment interactions (ATI), (Cronbach and Snow, 1977).

The ATI framework was selected deliberately since the study's general hypothesis posited an interaction: some children learn better when given some choice over the learning situation, while other children learn better when the learning situation is more structured for them. Given this general hypothesis, the first step in the design of this study was to identify learner characteristics or aptitudes that would potentially differentiate these two groups of children. More specifically, the design of the study called for the identification of motivational aptitudes that relate to choice behavior in educational settings.

To this end, a three-phase review of literature was conducted. In the first phase, studies investigating aptitudinal correlates of educational choice were reviewed. The few studies conducted in this area provided few ideas about student aptitudes that may interact with choice situations. The research review then shifted to studies investigating the relationship between educational achievement and locus of control (LOC), which was selected for its logical relationship to the ability to make choices. This second phase of the review indicated that the LOC-achievement relationship is not simple and linear, but instead moderated by complexities within the LOC construct itself and by other related

constructs. These complexities and moderating constructs were then further investigated in the third phase of the review, which focused on two major areas within the general body of literature on control and causality in learning situations. The first, in the domain of social learning theory, centers around the LOC construct and stems primarily from Rotter (1954). Secondly, from Heider (1958) comes research relating to causal attributions in the learning process. The review of these two areas resulted in the identification of four specific motivational aptitudes that have potentially interactive effects on learning in an educational choice situation: expectancy of success, importance or incentive value of success, causal attributions for academic performance, and evaluative orientation (towards externally-directed vs. self-initiated learning). (See Greene, 1976 for a presentation of the complete review of literature.)

Method

Subjects. Nine classes of students participated in this study. The nine classes were obtained from four public schools all located within the same middle class, predominantly Caucasian, professional community. Of the total 165 subjects, 91 were fourth graders and 74 were fifth graders.

Aptitude measures. An existing instrument was adapted or a new one developed for each of the four motivational variables identified in the review of literature. (Estimates of internal consistency reliability for each measure were satisfactory, in the .70's and 80's.) Measures of two cognitive aptitudes were also included to assess whether motivational aptitudes had effects on learning beyond those of ability (a procedure recommended by Cronbach and Snow). The two cognitive measures were pretest performance on the experimental learning task and performance on the Lorge-Thorndike Verbal and Nonverbal tests.

The four motivational measures along with the learning task pretest were administered as a pretest package to each class. Performance scores on the Lorge-Thorndike tests were obtained from school files.

Learning task. The experimental learning materials were based on the Thurstone Letter Series task, chosen for its novelty and its relevance to general problem solving goals of education. These materials included a Letter Problems Workbook consisting of eight lessons, each one constructed around a component skill required for the more general problem-solving strategy, and additional Practice Sheets of similar problems.

Outcome measures. Three learning outcomes, one cognitive and two motivational, were assessed: (1) performance on a letter series criterion test; (2) causal attributions for performance in the Letter Series Workbook; and (3) interest in learning more about the letter series task. The instruments developed for each outcome were administered as a posttest package to each class. (Again, estimates of internal consistency reliability for each measure were satisfactory.)

Treatment definition. Three dimensions of choice over learning procedure were manipulated by randomly dividing the subjects in each class into a choice group (n=84) and a no-choice group (n=81). (Since both treatments were implemented in each class, the study actually contained nine replications of the same design.) Choice subjects were given their choice of (1) when to do the Letter Series Workbook, time and pacing, (2) the sequence in which to complete the workbook, and (3) standards for performance on the workbook. No-choice subjects were asked to complete the workbook (1) at specified times, (2) in a specified order, and (3) according to externally-defined performance standards.

These educational choice dimensions were selected as representative of the actual types of choices presently offered to public school students. Yet, the meaning of educational choice can range along a continuum from choice over how to complete a required lesson (as in the present study) to choice over whether or not to attend school. Since different psychological processses are likely to be important for different types of eduational choices, the findings of this study may not be generalizable to broader choices of alternative learning tasks or of whether or not to complete a learning task at all. However, this question of generalizability is an empirical one, answerable only by a systematic investigation of the psychological meaning and learning consequences of the full range of choice in education.

Procedure. The study spanned a four-week period in each classroom. During the first week, the experimenter visited each classroom for about one hour to conduct the pretesting, introduce the Letter Problems Workbook, and divide the students within each class into the choice and no-choice groups. (Pilot results had indicated the within class treatment manipulation served to strengthen the overall design by making the choice/no-choice contrast highly visible.)

The second and third weeks were the workbook phase. During these two weeks, the no-choice group worked on one workbook lesson each day, Monday through Thursday of each week, during the 20 minutes the experimenter visisted the classroom. No-choice subjects completed the workbook in the order in which the lessons were presented. On Friday of each workbook week, the experimenter corrected and evaluated no-choice subjects' performance on the lessons completed. Choice subjects were irstructed to complete the workbook before the end of the two week workbook phase.

They could work on the workbooks whenever they had free time during school and/or when the experimenter visited the classroom to work with the no-choice group. Further, they could complete the lessons in an order of their own choosing. On Friday of each workbook week, when the experimenter visited the classroom to correct the no-choice group's work, choice subjects were given Answer Sheets and asked to correct and evaluate their own work.

Finally, the three posttests were administered during a half hour session at the beginning of the fourth week. At the end of this fourth week, the experimenter returned to each classroom to follow up on the interest posttest.

Analyses

Prior to investigating the major ATI hypotheses of the study, factor analyses were conducted on both the aptitude scores and the outcome scores in an effort to (1) reduce the numbers of variables in the data set, (2) avoid the problem of collinearity in multiple regression analyses, and (3) seek parsimony in the results.

A principal components analysis with varimax rotation on 15 aptitude scores yielded a six-factor solution, accounting for 75% of the variance. The first two factors were labelled G (general ability, but more nonverbal and problem-solving ability then verbal ability) and A (confidence and belief in one's ability to do well in school). A similar principal components analysis on 10 outcome scores yielded four orthogonal factors accounting for 72% of the variance. The first of these factors was labelled A', representing the belief the ability was the cause of performance in the workbook, combined with performance and interest learning outcomes. That is, this outcome factor A' is parallel

to the aptitude factors G and A, in that the cognitive aptitudes that loaded on G and the affective aptitudes that loaded on A are parallel to the cognitive and affective outcomes that loaded on A'. (The remainder of the aptitude and outcome factor solutions also showed parallels, with each outcome factor mapping on to one or more aptitude factors.)

The major hypotheses of the study were tested with a stepwise multiple regression analysis on each outcome factor. In addition, simple regression analyses on selected aptitude-outcome pairs (including G-A' and A-A') were conducted by treatment across all subjects, by treatment within each class, and by treatment between classes (using half-class means). The major purpose of these simple regression analyses was to explore the marked class differences evidenced throughout the data. Given the small n's, the simple regression results were noted as highly unstable. Nevertheless, the patterns of these results both highlighted the differential effects of treatment on individuals vs. classes, as well as led to substantive hypotheses about these effects. It is the results of these simple regression analyses for G-A' and A-A' that are the focus of this paper.

Results

Tables 1 and 2 and Figures 1 and 2 present the results of the simple regression analyses for G-A' and for A-A' by treatment and by treatment within class. Figures 3-6 show the corresponding scatterplots. In Figures 1 and 2 the within class lines were plotted to represent ± 1 SD around the bivariate mean. Given the small n's for these within class analyses, the results are clearly unstable. For this

reason, general patterns of differences, rather than actual R^2's or b's will be emphasized. (Classes #3 and #4 were excluded from these within class analyses due to extremely small n's.)

Also included in Figures 1 and 2 are between class regression lines, calculated from half-class means and thus also noted unstable. These between class lines were included, however, to investigate possible discrepancies between pooled results based on individuals and class results based on class means. As suggested by Cronbach and Webb (1975), a large discrepancy would indicate that the pooled line, assessing individual effects, is probably obscuring large class differences. In addition wide variation of the within class lines around the between class line is further evidence for large class differences. (Classes #3 and #4 were included in the calculation of the between class lines because means for these classes were generally consistent with the pattern formed by the other seven classes.)

Table 1

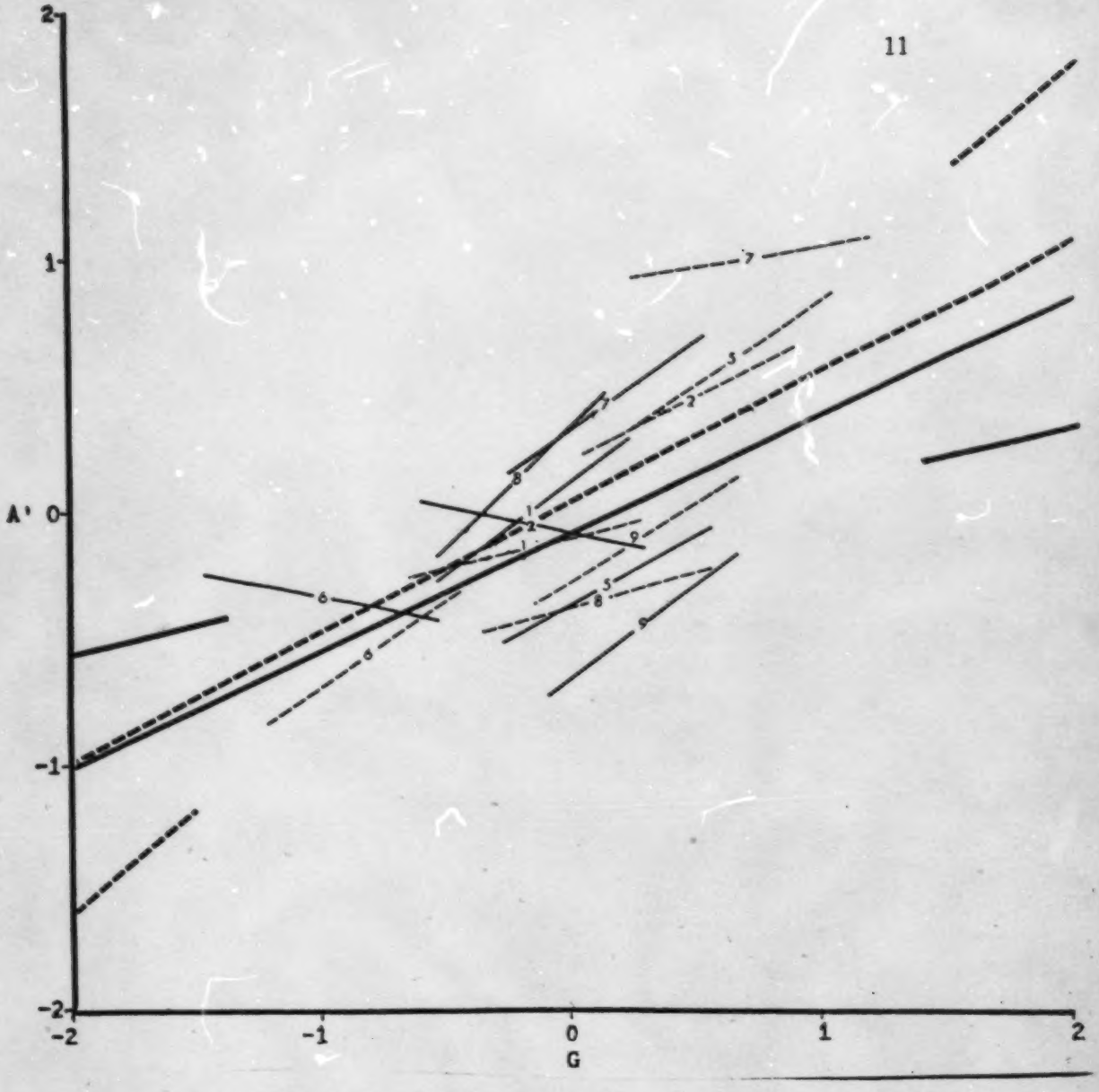
Results of Simple Regression Analyses by Treatment

	No-choice (n=81)			Choice (n=84)		
	R^2	b	Constant	R^2	b	Constant
G-A'	.19	.46	-.08	.30	.52	.07
A-A'	.03	.16	-.11	.17	.42	.07

Table 2

Results of Simple Regression Analyses by Treatment Within Class

	No-choice				Choice			
	n	R^2	b	Constant	n	R^2	b	Constant
G-A'								
Class #1	10	.42	.74	.12	12	.09	.20	-.11
Class #2	10	.04	-.22	-.07	7	.70	.49	.23
Class #5	10	.43	.56	-.36	12	.42	.63	.22
Class #6	9	.25	-.21	-.52	11	.43	.67	-.02
Class #7	12	.51	.70	.33	12	.21	.15	.93
Class #8	9	.84	.96	.33	11	.05	.29	-.36
Class #9	11	.24	.75	-.66	11	.30	.61	-.26
A-A'								
Class #1	10	.07	.33	-.03	12	.06	-.43	.08
Class #2	10	.03	-.14	.04	7	.01	-.13	.48
Class #5	10	.02	-.14	-.35	12	.02	.17	.51
Class #6	9	.01	-.07	-.30	11	.72	.87	-.64
Class #7	12	.49	.65	.78	12	.00	.02	1.03
Class #8	9	.26	.76	.55	11	.38	.56	.10
Class #9	11	.00	.04	-.44	11	.10	.23	-.11

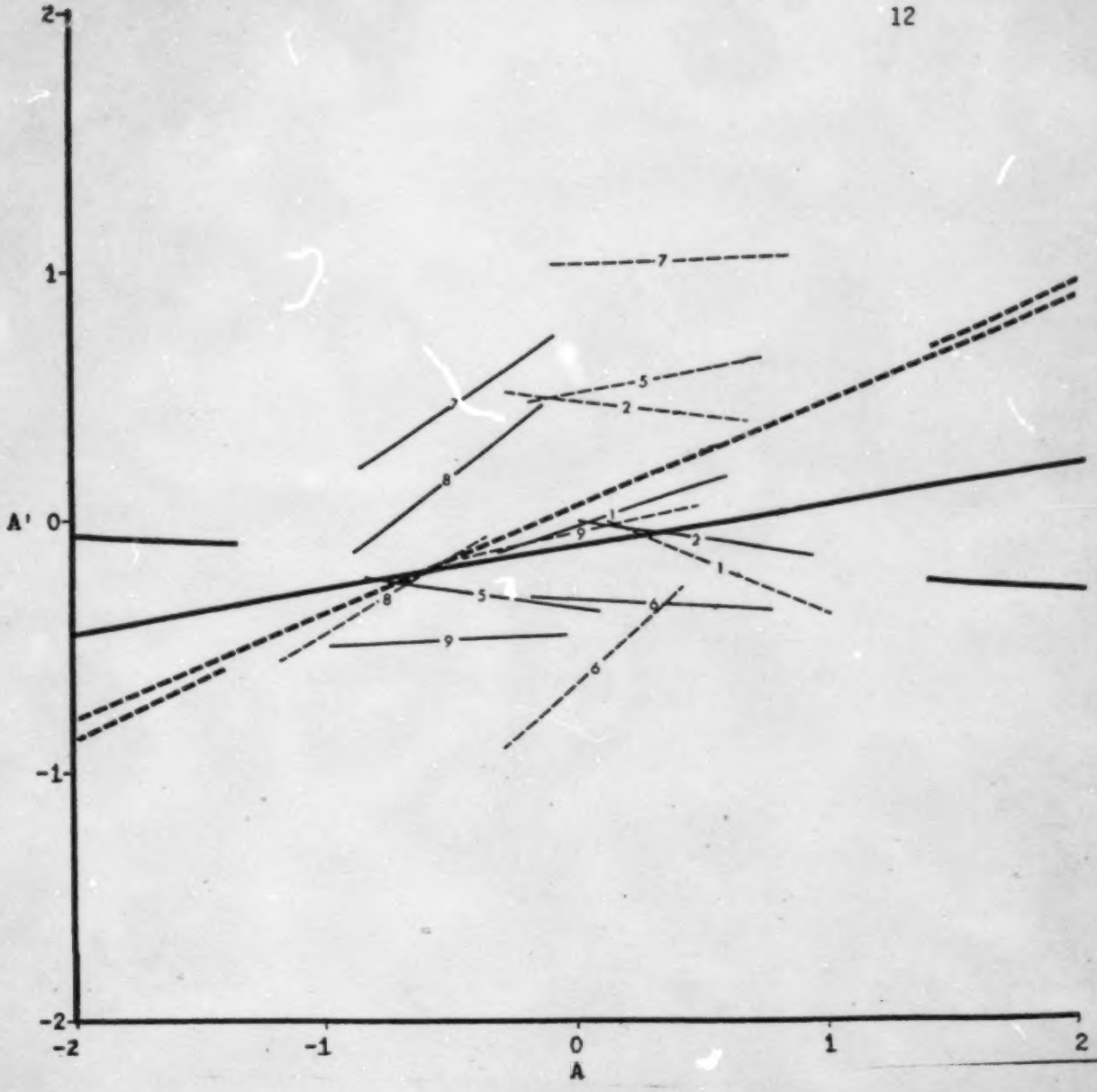


Pooled within No-choice treatment
Pooled within Choice treatment
i No-choice treatment within class i
i Choice treatment within class i
Between class, No-choice
Between class, Choice

Note: Sample range for G was -2.68 to 2.71
Sample range for A' was -2.47 to 1.82

Figure 1

Regression Lines for G and A'

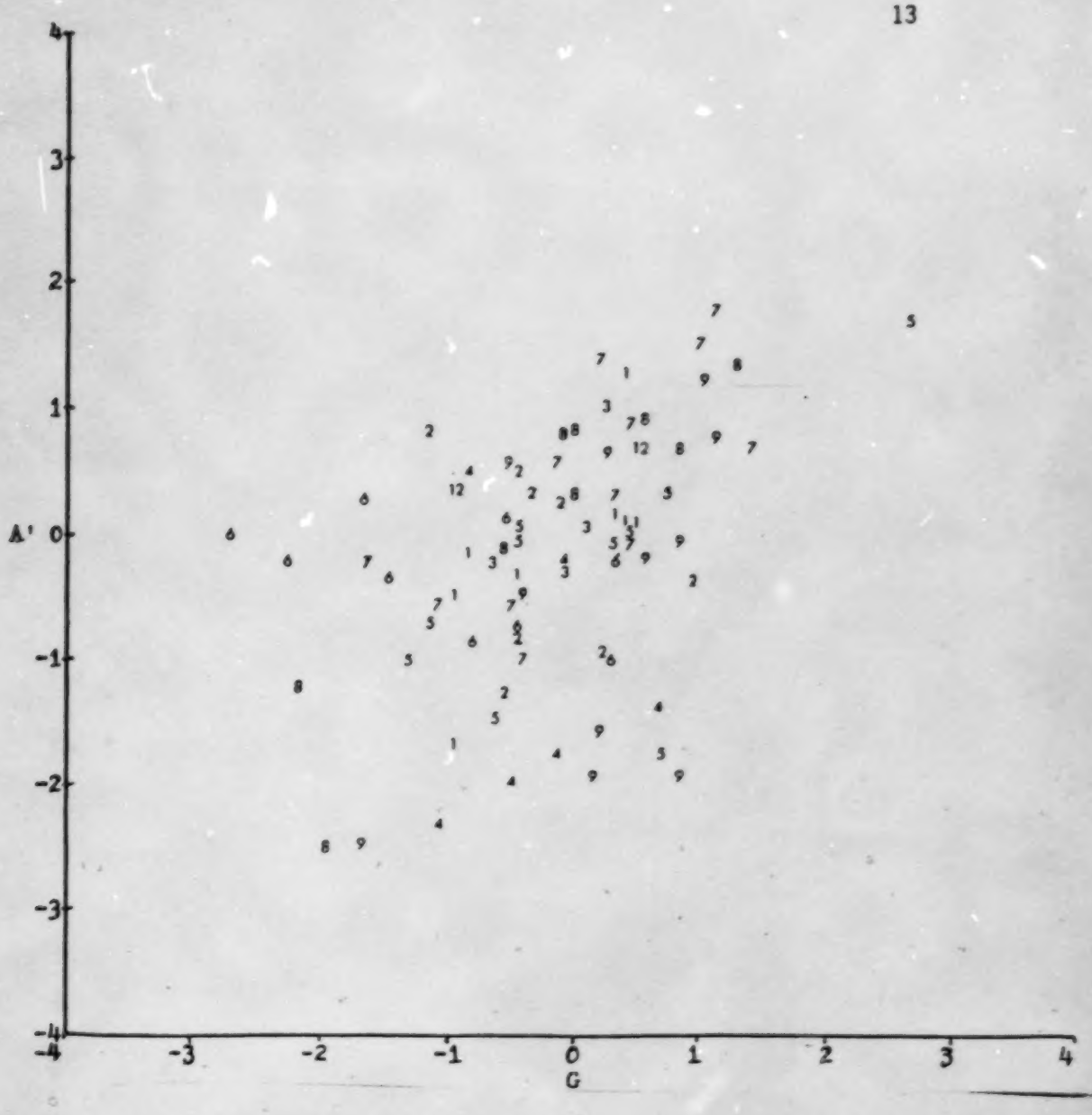


Pooled within No-choice treatment
Pooled within Choice treatment
—1— No-choice treatment within class i
--1--- Choice treatment within class i
— — Between class, No-choice
---- ---- Between class, Choice

Note: Sample range for A was -3.86 to 1.39
Sample range for A' was -2.47 to 1.82

Figure 2

Regression Lines for A and A'



1 - 9 Classes #1 - #9

Figure 3

G - A' Scatterplot for No-choice Group

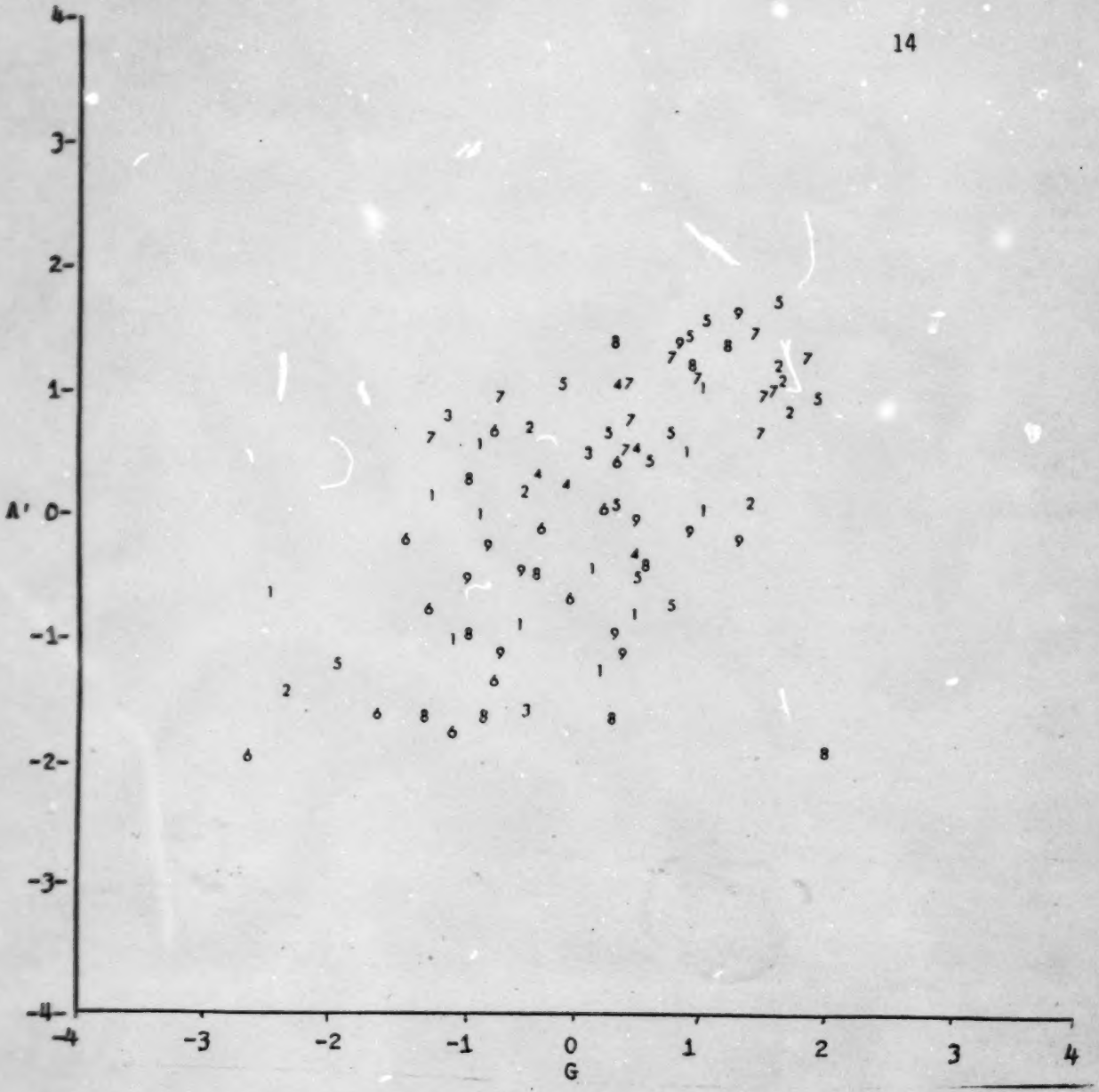


Figure 4

G - A' Scatterplot for Choice Group

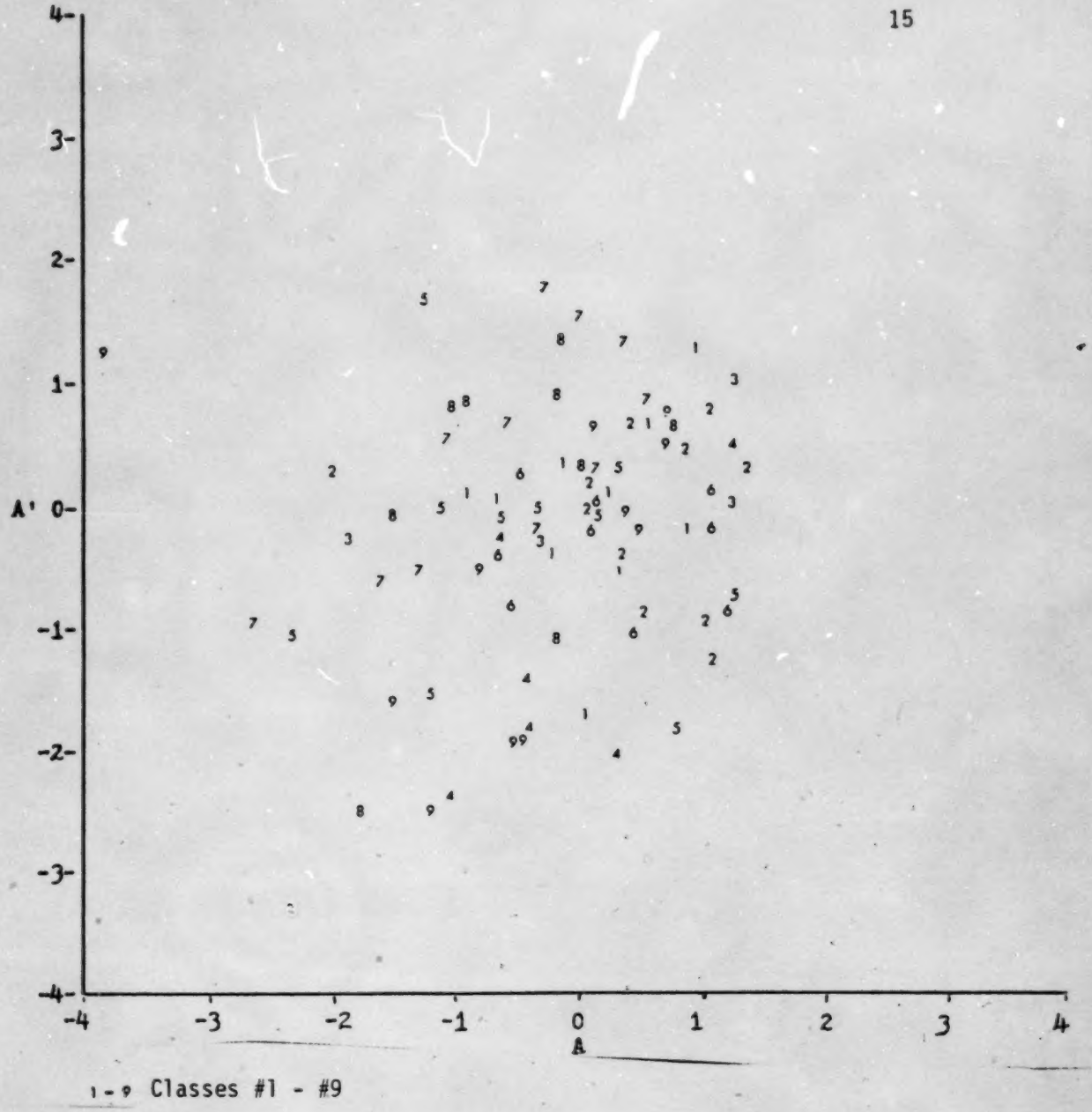


Figure 5

A - A' Scatterplot for No-choice Group

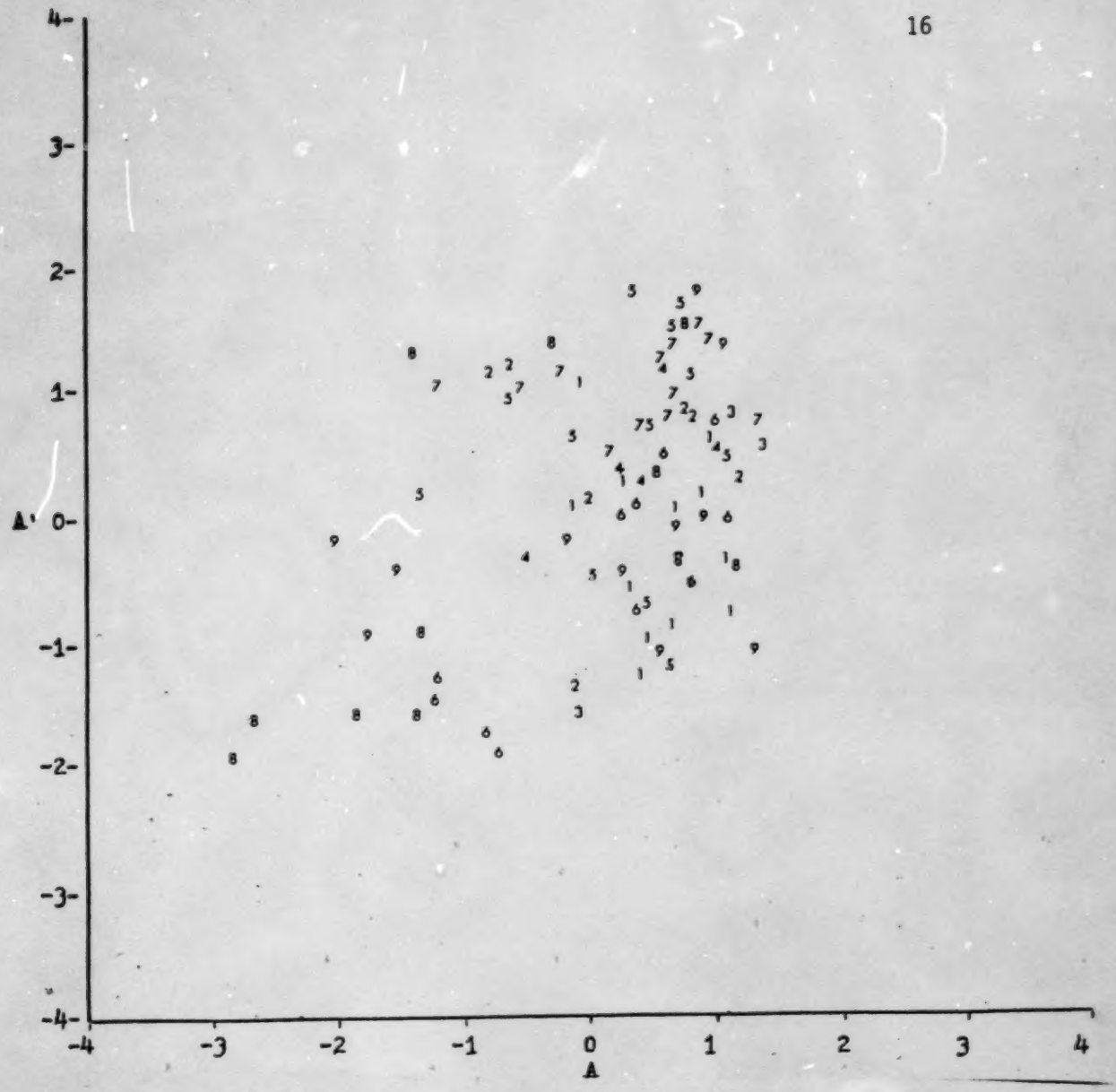


Figure 6

A - A' Scatterplot for Choice Group

G-A'

Looking first at the results for G-A', the choice and no-choice pooled regression lines are almost parallel, corresponding to the lack of significant ATI's in the multiple regression and implying no differential effects of treatment on A' for individuals with different levels of G. Rather, individuals with higher levels of G performed better than individuals with less G in both the choice and no-choice treatments.

However, the within class results show a different pattern, the most striking aspect of which is the wide variation among classes. Classes #5 and #9 show a pattern similar to the overall pooled results, with both regression lines essentially parallel, implying no differential effects of treatment. In classes #1, #7, and #8, both lines are positive but the no-choice line is steeper. This suggests that in those three classes, subjects with relatively high G performed substantially better than subjects with relatively low G in the no-choice treatment, but only slightly better in the choice treatment. Finally, results for classes #2 and #6 show an ATI pattern in that the choice line is positive and the no-choice line negative. This suggests that in these two classes, subjects with relatively high G performed best in the choice treatment while subjects with relatively low G performed best in the no-choice treatment.

The between class regression lines for G-A' also show a pattern different from that of the pooled lines. Although the pooled lines are almost parallel, the between class lines are suggestive of a sizeable ATI. Such an interaction would indicate that the choice/no-choice treatment manipulation interacted with classroom characteristics associated with average G or ability level: students in high (average)

ability classes benefitted from having choice, while students in low (average) ability classes learned better with structure. Finally, the within class lines show considerable variation around the between class lines, further attesting to the existence of large classroom differences.

A-A'

Similar discrepancies are revealed by the three sets of regression lines for A-A'. The pooled regression lines do show an interaction. (This is consistent with the multiple regression results, although the A x treatment interaction accounted for only 2% of the variance.) The A-A' no-choice line is almost flat, while the A-A' choice line is strongly positive, signifying a much stronger relationship between these two variables in the choice group.

Yet, in none of the classes is the pattern of within class results similar to this pattern of pooled results. In classes #8 and #9 both lines are positive and essentially parallel, implying that in these two classes, students with greater confidence performed better than students with less confidence irrespective of treatment. In class #2 both lines are also parallel but are negative in slope, again implying no differential effect of treatment and a general posttest superiority of students low in confidence. In class #7 both lines are positive but the no-choice line is steeper. In the remaining three classes (#1,#5, and #6), the two regression lines have opposite slopes and thus form an ATI.

For A-A' the between class regression lines show a considerable discrepancy from the pooled regression lines for the no-choice group but not for the choice group. However, the two between class lines form an ATI similar to that shown by the between class lines for G-A'. That is,

in relatively high confidence classes, the mean performance of choice subjects was considerably greater than that of no-choice subjects. In relatively low confidence classes, the pattern was reversed: mean performance of no-choice subjects was considerably greater than that of choice subjects. In other words, the choice/no-choice treatment manipulation interacted with classroom characteristics related to academic confidence.

Discussion

Once again, it should be emphasized that because of limited sample sizes the results in this paper are not presented as supportive evidence for a given psychological theory or as conclusive evidence for a given learning phenomenon. Rather, they are presented as illustrations of the possible magnitude of social effects in ATI's arising from classroom characteristics and as a basis for substantive hypotheses about these effects.

In the results for the two selected aptitude-outcome pairs (G-A' and A-A'), the pooled regression lines either showed no interaction (G-A') or a slight interaction (A-A'). In practical terms the pooled regression lines indicated that students with high ability or high confidence performed better than students with low ability or confidence both when given some choice in the learning situation and when the learning situation was more structured for them.

Further analyses, however, both within class and between classes suggest that these pooled regression lines were obscuring large class differences. The between class results for both G-A' and A-A' showed similar ATI's. In practical terms, these ATI's suggest that students in high ability or high confidence classes learned better when given some

choice, while students in low ability or low confidence classes learned better under more structured conditions. That is, the significant interaction was not with individual student aptitudes, but rather with the social effects of being a member of a class that was relatively high or low in ability or academic confidence. Such social effects might have operated as follows. Choice subjects in high ability classes may have experienced a mutually felt motivation or challenge and, in low ability classes, a common threat, uncertainty, or abandonment. No-choice subjects in high ability classes may have shared frustration at being held back and, in low ability classes, confidence in not having to make all the decisions. This line of interpretation implies that, although the major ATI hypotheses of the study were not confirmed for individual aptitudes, they may have been confirmed for social or classroom characteristics.

The markedly divergent patterns of within class results provided additional evidence indicative of large class differences. In some classes results suggested that there were no differential effects of treatment. In others one treatment seemed to have different effects on subjects with different levels of ability or confidence, while the other treatment did not have differential effects. In still other classes treatment interacted with ability or confidence in the formation of an ATI. In the absence of systematic assessments of classroom characteristics within the experimental design, an informal, post hoc effort was made to find some possible explanations for the widespread class differences. This effort included categorizing the different patterns of within class simple regression results and ranking the nine classes on selected dimensions relating to choice and structure in the classroom.

Resulting from this informal assessment were hypotheses about class differences based on the degree to which one or the other experimental treatment was similar to everyday classroom experiences. For example, several patterns of results suggested that students high in the given aptitude performed best in the treatment most similar to normal classroom procedure, while students low in the aptitude performed best in the treatment most different from everyday classroom procedures.

In summary the results of this study provide tantalizing evidence that significant interactions might not have occurred with individual aptitudes but may have occurred with some kind of classroom characteristics. Possibly relevant classroom characteristics include the social effects of being a member of a high vs. low ability or confidence class and the degree to which the experimental treatments were similar to everyday classroom procedures. Future ATI research in this area would benefit enormously from the identification and inclusion of relevant classroom characteristics in addition to relevant learner aptitudes.

Methodological Implications

As Cronbach and Snow (1977) so clearly point out, recognition of the importance of classroom effects "forces a radical change in thinking about ATI" (p. 100). Part of this change calls for the separation of treatment, between class, and within class effects in analyzing possible interactions. To continue to assume that ATI effects operate independently in different individuals is to ignore a priori the existence of social effects. This change in thinking about ATI further implies that in ATI research conducted with classroom groups, classes rather than individuals are the proper unit of analysis for statistical

inference. Furthermore, following from Cronbach and Snow's earlier rule of thumb, samples of 100 classes per treatment are needed to detect aptitude main effects or ATI's with sufficient power. In full recognition that such sample sizes are well beyond the resources of most researchers, Cronbach and Snow advise ATI researchers to rely more heavily on "the theoretical coherence of the results" (p. 104) than on the statistical significance of the results.

The results of this study provide an additional methodological suggestion that may be of value to some ATI researchers. Unlike most studies, in which whole classes are assigned to one treatment, all classes in this study were exposed to both treatments. This component of the study was designed deliberately to heighten the contrasts between the choice and no-choice treaments, which in actuality, were quite small. This design component further allowed for the analysis of within class effects of both treatments, rather than just one. The within class analyses therefore consisted of nine mini-ATI's, all paralleling the pooled within treatment ATI analysis. With this procedure the class x aptitude and class x aptitude x treatment interactions are distinguishable.

The major limitation of this kind of design remains, of course, the limited sample sizes for the within class analyses. Nonetheless, the designed implementation of two experimental treatments in each classroom group may be a valuable methodological strategy for ATI researchers interested in (1) strengthening the treatment contrast and/or (2) assessing ATI's for different kinds of learners within the same class and for the same kinds of learners in different types of classes.

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